Juice From Juice

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Abstract

Throughout this project various dyes, natural and synthetic, were tested for their efficiency in converting incoming light into electrical energy. The synthetic dyes tested were coumarin 153 and Rhodamine 560, and the natural dyes were Anthocyanin and Lycopene. Anthocyanin was extracted from cranberries and Lycopene was extracted from a papaya. Test slides were created by sintering Titanium dioxide onto conductive glass plates, and a solution of pigment and Iodine was deposited between this layer and another conductive glass plate. For each dye 10 different slides are tested for efficiency. The highest efficiency was the natural dye, anthocyanin which had an average efficiency of 12.6 %

Introduction

The focus of this project was to design and test a Dye Sensitized Solar Cell (DSSC) with maximum solar conversion efficiency. DSSCs, which use metal oxides and pigments as opposed to silicon, reducing the production cost albeit with lower efficiencies. A variety of plant pigments were extracted and tested in these cells, specifically anthocyanin (cranberries) and Lycopene (papaya). Synthetic dyes were used as well; specifically Couramin 153, and Rhodamine 560. The pigments were deposited onto layers of titanium dioxide which was deposited on conductive glass electrodes in order to make cells. These plates were tested to see how efficiently they converted incoming light into electrical power given variations in a number of parameters.

Apparatus-Centrifuge

The centrifuge was used to efficiently extract pigment from a solution of equal parts, by volume, of acetone, hexane, and plant pulp. These solutions were first put through a blender, and the photosynthetic pigments were extracted from the solutions once separated in a centrifuge put at 14,000 rpm (Corresponding to 33,000 gs of acceleration) for 1 minute.

Apparatus – The DSSC

Of the plant pigments used in this study three: chlorophyll, beta-carotene, and xanthophyll were extracted using a mixture of hexane and acetone and one: anthocyanin was extracted using water. The plants used as pigment sources were carrots (beta-carotene), yellow peppers (xanthophyll), majesty palm (chlorophyll), and raspberries (anthocyanin). Glass, coated in a transparent layer of tin fluoride oxide (TFO) was coated with a layer of titanium dioxide (TiO2) and then sintered using a hot plate on high for thirty minutes. The plates were soaked in the dye mixtures for about five minutes in order to allow the pigments to bind to the TiO2 layer. Another piece of conductive glass, with an additional layer of conductive graphite was placed over the glass coated with TiO2 and was attached using binder clips. Iodine was applied in between the two pieces of glass using capillary action to act as the electrolyte (See fig 1 below).

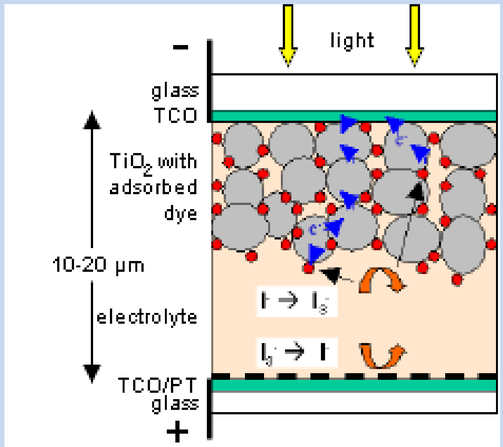


Fig. 1: Schema of dye-sensitezed solar cell

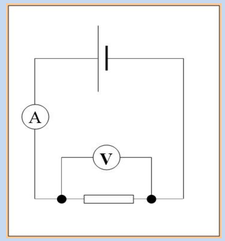
Experimental setup

Pigment Extraction:
Two pigment extraction processes were used. The lycopene pigment at first was being extracted by mixing blended papaya with a 50/50 proportion of acetone and hexane to draw to active pigments in a separate layer for extraction. This extraction was a slower process so afterwards the centrifuge was used to speed up the process. The anthocyanin pigment was as well mixed with the same proportion of acetone and hexane, which was then put into the centrifuge to speed up the extraction process.

Plate Assembly:
A layer of TiO2, of approximately 0.1mm thickness, is sintered onto conductive glass plates which act as the cell electrode. The number of layers was varied from one to three in order to study its impact on cell efficiency. A counter-electrode is then assembled with another piece of conductive glass covered in a thin layer of graphite. The cell is then assembled with the TiO2, pigment, and iodine between the electrode and counter-electrode and held together with

Apparatus – Test Circuit

An ammeter was attached in series to the DSSC and a potentiometer in order to record the generated current. In parallel to this circuit was attached a voltmeter in order to record generated voltage. The peak power in watts was as the product of the current and voltage while the resistance was changed in order to find the peak power output. (See fig2 below)



Results – Efficiency

Pigment	Average Cell Efficiency %	Standard Deviation on Efficiency %
Couramin 153	0.7	0.4
Rhodamin 560	0.5	0.5
Lycopene	5.3	8.4
Anthocyanin	12.6	17

References and Acknowledgements

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References:
[1] *Dye-sensitized solar cells,* http://en.wikipedia.org/wiki/Dye-sensitized_solar_cell
[2] *Electric Circuits*, http://www.scienceaid.co.uk/physics/electricity/images/seriescircuit.jpg
[3] *Titanium Dioxide Raspberry solar Cell,* http://mrsec.wisc.edu/Edetc/nanolab/TiO2/index.html
[4] *ccisolar.caltech.edu* http://ccisolar.caltech.edu/images/energetics-DSSC.jpg
[5] *The potential of natural photosynthetic Pigments to Improve the Efficiency of Dye Sensitized Solar Cells* : Eran Barnoy, Mark Conley, A. Stephan Gan, Yoni Gefen, Jana Lovell, Katherine Mann, Adin Shuchatowitz, Christine Tobin ; Digital Repository at the University of Maryland